

<b>GEARTECH</b>	QUALITY PROCEDURE	No. QP4400	SHEET 1 OF 4	
		Rev. A		
Seal Design Audit		BY RLE	DATE	6/08/00
		CKD JRM	DATE	6/08/00
<div>1. Scope</div> <div>1.1 This procedure covers auditing of design features of seals for conformance to AGMA/AWEA 921-A97 and the procurement specification.</div> <div>2. Referenced Documents</div> <div>2.1 AGMA/AWEA 921-A97 Recommended Practices for Design and Specification of Gearboxes for Wind Turbine Generator Systems.</div> <div>2.2 GEARTECH Specifications:</div> <div><div>CK1000</div><div>QP1000</div><div>Procurement process</div></div> <div><div>CK2000</div><div>QP2000</div><div>Procurement specification</div></div> <div><div>CK3000</div><div>QP3000</div><div>Bid solicitation and evaluation</div></div> <div><div>CK4000</div><div>QP4000</div><div>Gearbox design audit</div></div> <div><div>CK4400</div><div>QP4400</div><div>Seal design audit</div></div> <div><div>CK5000</div><div>QP5000</div><div>Quality assessment</div></div> <div><div>CK6000</div><div>QP6000</div><div>Quality assurance plan</div></div> <div><div>CK7000</div><div>QP7000</div><div>Manufacturing schedule</div></div> <div><div>CK8000</div><div>QP8000</div><div>Manufacturing audit</div></div> <div>3. Terminology</div> <div>3.1 Lip seal- Elastomeric seal that depends on an interference fit between the shaft and seal lip. When operating properly, the lip rides on a thin film of oil.</div> <div>3.2 Single/double lip seal- Single lip seals have only a primary lip intended for sealing oil. Double-lip seals include a secondary lip intended for sealing external contamination.</div> <div>3.3 Labyrinth seal- Non-contacting seal that depends on close radial clearance between the shaft and seal lands.</div> <div>3.4 V-ring- All-rubber seal that mounts directly on the shaft and seals axially against a counterface such as a housing cap.</div> <div>3.5 Viton®- Viton is a registered trademark of E.I. DuPont. It is a Fluoroelastomer capable of high temperature operation with good resistance to lubricant additives.</div> <div>3.6 Material compatibility- Resistance of an elastomer to adverse reactions to gear lubricants. Properties such as durometer, compression set, swelling, hardening and cracking are important.</div> <div>4. Significance and use</div> <div>4.1 Design audit- The seal design audit is necessary to ensure seals meet requirements of the procurement specification and have proven technology for the application.</div> <div>5. Procedure</div> <div>5.1 Checklist and quality procedures- CK1000 through CK4000 and QP1000 through QP4000 shall be used as guidelines for required data for seal design audits. CK4400 shall be used as a guideline for seal design audits. See CK5000 through CK8000 and QP5000 through QP8000 for guidelines for quality assurance.</div>				

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5.2	Specification conformance- Seal design documents shall be reviewed for conformance with AGMA/AWEA 921-A97 and the procurement specification.			
5.3	Seal features- Features such as manufacturer, type, size, and material shall be compared to requirements of AGMA/AWEA 921-A97 and the procurement specification.			
5.4	Labyrinth seals			
5.4.1	Geometry- The number and geometry of grooves shall be determined from engineering drawings.			
5.4.2	Shaft clearance- The range of clearance with shafts shall be calculated from tolerances given on engineering drawings.			
5.4.3	Oil level- The distance from the lowest labyrinth groove and the static oil level shall be determined from engineering drawings considering orientation of the gearbox in the installed position.			
5.5	Lip seals			
5.5.1	Geometry- The number and geometry of sealing lips shall be determined from engineering drawings.			
5.5.2	Shaft interference- The range of interference with shafts shall be calculated from tolerances given on engineering drawings.			
5.5.3	Material- Elastomer composition shall be determined from engineering drawings.			
5.5.4	Endplay- The range of shaft endplay shall be determined from engineering drawings.			
5.5.5	Lubrication- Provisions for supply of lubricant shall be determined from engineering drawings.			
5.5.6	Maintainability- Provisions for replacing seals in-situ shall be determined from engineering drawings.			
5.6	External contamination- Seal design shall be reviewed considering risk of contamination from environmental dirt and water.			
5.7	Internal contamination- Seal design shall be reviewed considering risk of contamination from internally generated wear debris.			
5.8	Seal assembly- Gearbox assembly shall be reviewed considering risk of damage to seal components.			

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6.	Interpretations of results			
6.1	Specification conformance- Results of the seal design audit shall be compared to requirements of AGMA/AWEA 921-A97 and the procurement specification for the following categories: <ul style="list-style-type: none"><li>• Seal features</li><li>• Geometry</li><li>• Shaft clearance/interference</li><li>• Surface roughness</li><li>• Oil level</li><li>• Material</li><li>• Endplay</li><li>• Lubrication</li><li>• Maintainability</li><li>• External/internal contamination</li><li>• Seal assembly</li></ul>			
7.	Acceptance criteria			
7.1	Seal features- Seal features shall meet the requirements of AGMA/AWEA 921-A97 and the procurement specification. Labyrinth seals shall be specified wherever possible, especially on high-speed shafts.			
7.2	Geometry- Labyrinth seals shall have at least two grooves. Lip seals shall have single lips.			
7.3	Shaft clearance/interference- Labyrinth seals shall have adequate clearance with shafts. Lip seals shall have interference with shafts meeting seal manufacturers recommendations.			
7.4	Surface roughness- Surface roughness of shaft surfaces shall be $Ra \leq 1.6 \mu m$ for labyrinth seals and $Ra \leq 0.3 \mu m$ for lip seals. Roughness lay for lip seals shall conform to seal manufacturer recommendations.			
7.5	Oil level- Labyrinth seals shall be at least 20 mm above the oil level.			
7.6	Material- Elastomer material shall be compatible with the gearbox lubricant. Viton is preferred if it is compatible with the gearbox lubricant.			
7.7	Endplay- All seals shall be capable of accommodating shaft endplay.			
7.8	Lubrication- All lip seals shall have an adequate supply of oil to the sealing lip.			
7.9	Maintainability- All seals shall be designed to be readily replaceable in-situ. Drive train configuration and component interfaces shall facilitate in-situ inspection and replacement of all seals.			

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7.10	External contamination- V-rings shall be specified to exclude environmental dirt and water.		
7.11	Internal contamination- Lip seals shall have oil slingers to protect sealing lips from contamination from internally generated wear debris.		
7.12	Seal assembly- Adequate tooling and procedures shall be provided to avoid damage to seal components. Shaft and housing dimensions for lip seals shall conform to seal manufacturer recommendations. Lip seals shall be pressed into retainers with tools that apply pressure only at the outer edge of the seal. Hammers shall not be used.		
8.	Report		
8.1	Report- The report shall include the following:		
8.1.1	Summary of seal features,		
8.1.2	Summary of geometry,		
8.1.3	Summary of shaft clearance/interference,		
8.1.4	Summary of surface roughness,		
8.1.5	Summary of oil level,		
8.1.6	Summary of material,		
8.1.7	Summary of endplay,		
8.1.8	Summary of lubrication,		
8.1.9	Summary of maintainability,		
8.1.10	Summary of external/internal contamination,		
8.1.11	Summary of seal assembly,		
8.1.12	Recommendations for revisions to engineering specifications to ensure conformance to AGMA/AWEA 921-A97 and the procurement specification.		

